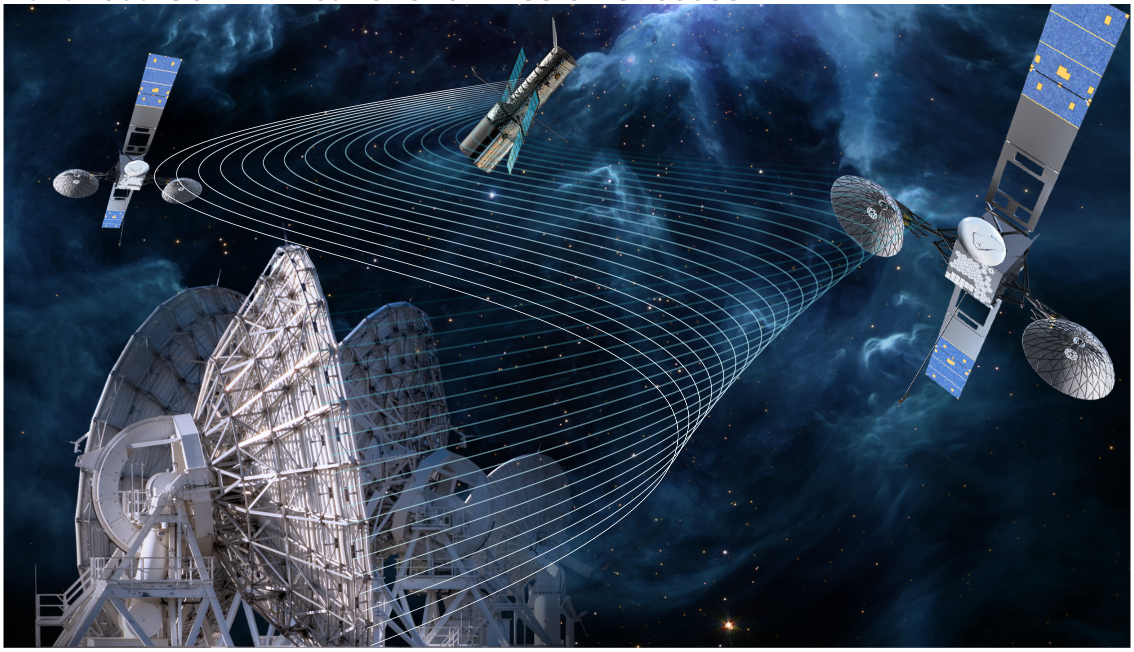
National Aeronautics and Space Administration

Exploration and Space Communications: Advanced Communications for Mission Success



NASA spacecraft have garnered worldwide recognition and praise for the level of precision and sophistication they have reached—yet their scientific value could not be realized unless the data is delivered to Earth. The Exploration and Space Communications (ESC) Projects Division, located at the Goddard Space Flight Center (GSFC) in Greenbelt, MD, employs equally sophisticated tracking instruments in conjunction with cutting-edge communication technology to enable these missions to achieve their scientific goals. ESC provides the vital link that enables advanced communications for mission success.

The ESC has a long and proud history, having provided critical support to a large volume and variety of NASA missions over many years. Space communications was built from the ground up—literally. The complex system used today started off as a network of ground antennas. By the time Astronaut John Glenn became the first American in orbit in 1962, NASA had established 30 ground stations on five continents and several islands. Yet despite continued expansion throughout the 1960s and 1970s, the network's potential to track orbiting spacecraft was limited to 10% to 20% of an orbit. This caused a significant lapse in communication for the majority of the satellite's lifespan. With the advent of the Tracking and Data Relay Satellites (TDRS) in the 1980s, NASA's space flight tracking and communication network evolved into a network including ground and space-based antennas. A constellation of relay satellites and supporting ground terminals now enable uninterrupted global communication among low-Earth Orbiting (LEO) spacecraft and the ground. Today, NASA offers robust communication and navigation services, applying either space-based or ground-based assets, or a combination of both to fully meet a customer's needs.

For over the past 50 years, GSFC has maintained three of NASA's networks for the Space Communication and Navigation (SCaN) program office. These networks are used to support missions between the Earth and the Moon:

- The Space Network (SN) controls an on-orbit fleet of Tracking and Data Relay Satellites (TDRS) that provide full-orbit, highly-reliable communications and tracking services for human spaceflight and robotic spacecraft.

- The Near Earth Network (NEN) consists of ground-based antennas located around the world. The NEN implements low-cost, low-risk solutions, by integrating NASA-owned facilities with international and commercial services to provide near Earth communications and tracking capabilities.

- The Satellite Laser Ranging (SLR) Network uses a worldwide network of lasers to provide highly accurate information on satellite orbits.

Space Network

The SN was established in the early 1980s to reduce reliance on NASA's worldwide network of ground tracking stations and to complement their capabilities. A study done in the 1970s, based on a theory by Arthur C. Clarke, recommended geosynchronous satellites to transmit data to and from the LEO satellites that were being used as remote data sensors. A modification to this basic concept allowed the system to operate from a single ground station located in the United States, thus marking the birth of the SN concept.

The SN has launched 11 TDRSs and built a total of three ground stations to accommodate an ever-increasing demand for around-the-clock service. This network operates as a data relay system between customer on-orbit platforms and customer ground facilities.

The SN is developing the third generation TDRSs, which will add satellites to the constellation, enhancing the robustness and capacity of the TDRS fleet. In addition, the SN Ground Segment will be significantly updated to provide new and improved capabilities, such as higher data rates and additional customer interface options.

NASAfacts

Near Earth Network

NASA has provided high-quality, ground-based tracking, telemetry and command (TT&C) services through the NEN since the agencies first satellite missions in 1958. The NEN continuously evolves to meet the changing communication needs of its customers.

NASA implemented its first ground-based communications network—the Manned Space Flight Network (MSFN)—in the 1960s. The MSFN was a worldwide communications network with stations primarily located at low-latitudes to support the Mercury, Gemini, and Apollo Programs. During this time, NASA also acquired responsibility for the Department of Defense's Minitrack system. Building upon this early network, NASA developed the Satellite Tracking and Data Acquisition Network (STADAN) to support an emerging class of satellites requiring enhanced communications.

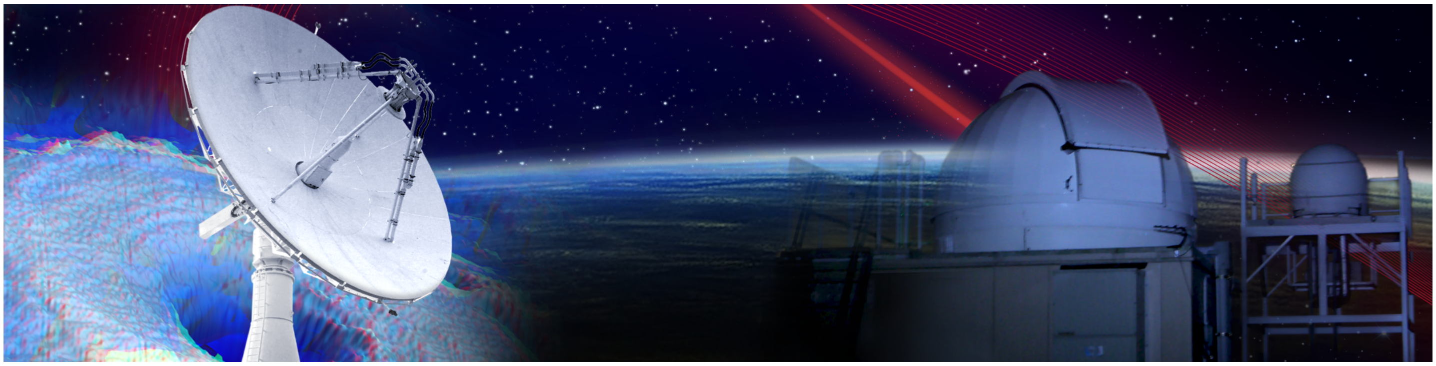
During the 1970s, NASA merged the MSFN and STADAN, forming the Spaceflight Tracking and Data Network (STDN). This was done in an effort to support the communications needs of manned and unmanned spacecraft missions. During the 1980's and 1990's, the STDN was expanded to provide crucial support to human spaceflight and to a new generation of polar-orbiting climate missions.

Satellite Laser Ranging

Laser Ranging is a fundamental measurement technique used by NASA to support both national and international programs in Earth dynamics, ocean and ice surface altimetry, navigation, and positioning. The SLR network is composed of a global network of stations to measure distances by bouncing very short pulses of laser light off special satellite-based reflectors. By accurately timing the round-trip time of flight of these pulses, distances can be computed and precise orbits determined.

NASA GSFC was the first to successfully demonstrate laser ranging to satellites in 1964. The NASA SLR Network has been fully operational in the field for over thirty years at fixed domestic and international sites ranging from California to South Africa.

During this time, the Network has seen many modifications and upgrades to maintain system operations and, more importantly, to increase the quantity and quality of data products. Working as part of the International Laser Ranging Service (ILRS), GSFC has played a crucial role improving ranging precision by a factor of a thousand from a few meters to a few millimeters.



Today, the NEN utilizes a diverse set of resources to provide high-quality services at the lowest cost to support flight missions. A key enabler to providing low cost services is the NEN Project's unique business practice of carefully blending the use of antennas operated by international space agencies and commercial partners with NASA-owned assets to fulfill the changing needs of the NEN-supported mission communications requirements.

The NEN Project pioneered the practice of procuring commercial TT&C services on a large scale. Currently, the NEN provides approximately half of its services using commercial and partner providers. Project goals include furthering this business model to maximize efficiencies between commercial providers and NASA systems and stations.

The NEN provides TT&C services to missions during pre-flight, launch, and on-orbit phases. NEN customers include NASA's Science, Human Exploration, and Operations Mission Directorates, as well as other government agencies, international civilian space agencies, and commercial entities.

Looking to the future, the NEN will be deploying higher-rate 800 Mbps X-band receiving capabilities and researching locations for additional Ka-band apertures (1+ Gbps). Furthermore, new coding and modulation schemes will be deployed to enable improved forward error correction and efficient bandwidth utilization.

Looking Forward

The future of space communications will include use of optical light in addition to radio waves. Building upon existing expertise in Satellite Laser Ranging, ESC developed the Lunar Laser Communication Demonstration (LLCD) which which launched on the LADEE Spacecraft in September 2013. Following LLCD, the Laser Communications Relay Demonstration (LCRD) will evaluate and validate the technical requirements of laser communication over a long period of time to support future optical communications users in Earth orbit.

Optical communication has the potential to enable 1+ Gbps data rates while greatly reducing the mass and power of satellite transponders.

Engage ESC

ESC works with new mission designers, Principal Investigators, Project Managers, and scientists to formulate the design of their communication systems. For example, at GSFC's Mission Design Laboratory (MDL), ESC assists customers in developing a mission's navigation and communication requirements to ensure its success. ESC's Networks Integration Management Office (NIMO) serves as the interface between the customers and GSFC's communications networks. NIMO provides options, analysis, planning, and testing assistance to ensure networks integration while meeting customers' technical and budgetary requirements. NIMO coordinates support from service providers throughout NASA, as well as other US agencies, foreign governments, and commercial entities.

Contact NIMO today and start communicating with us so your mission can communicate with you.

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NP-2011-11-118-GSFC (REV OCT 2013)